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On the VUV and UV $4f^7(^8S)5d \rightarrow 4f^8$ interconfigurational transitions of Tb^{3+} ions in $LiLuF_4$ single crystal hosts

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Abstract

The laser induced fluorescence spectrum of Tb^{3+} ions in $LiLuF_4$ single crystals, pumped by a fluorine pulsed discharge molecular laser at 157.6 nm, was obtained in the vacuum ultraviolet (VUV) and ultraviolet (UV) regions of the spectrum. The $4f^7 5d \rightarrow 4f^8$ dipole allowed transitions originate from the Stark components and the edge of the levels of the $4f^7(^8S)5d$ electronic configuration. The LIF spectra were interpreted on the basis of phonon trapping and phonon reabsorption within the levels of the $4f^7 5d$ electronic configuration. The absorption spectrum of the crystal samples in the VUV was obtained as well. We observed eight transitions between the ground level $4f^8(^7F_6)$ and the Stark components of the levels of the $4f^7(^8S)5d$ electronic configuration and five transitions between the ground level $4f^8(^7F_6)$ and the Stark components of the levels of the $4f^7(^6P)5d$ electronic configuration. The edge of the levels of the $4f^7 5d$ electronic configuration was found to be at $45.2 \times 10^3 \pm 0.2 \times 10^3$ cm^{-1} and the band gap of the crystal host was $77.6 \times 10^3 \pm 0.3 \times 10^3$ cm^{-1} wide.

1. Introduction

The vacuum ultraviolet (VUV) and ultraviolet (UV) absorption and emission spectroscopic characteristics of the rare earth (RE) ions, activated in the wide band gap of fluoride dielectric crystals, suggest that they can be used for a variety of applications, such as generation of laser light [1–3], light waveguides [4–6] and luminescence materials for new types of fluorescence bulbs [7,8]. The absorption and the emission spectra are mainly due to the transitions between the levels of the $4f^n$ electronic configuration and the levels of the $4f^{n-1}5d$ electronic configuration of the trivalent RE ions (where a 4f electron is promoted to a 5d localised band). These transitions, with strong Franck–Condon factors, are responsible for the broad band absorption and emission spectra. Because the energy levels of the $4f^{n-1}5d$ electronic configuration of the RE ions are situated 6–10 eV above the ground level of the $4f^n$ electronic configuration, various experimental methods have been applied for the excitation of the $4f^{n-1}5d$ electronic configuration, such as excitation with synchrotron and X-ray radiation sources [9,10] and multiphoton stepwise excitation [11,12]. In this paper, we report on the interconfigurational $4f^7 5d \rightarrow 4f^8$ VUV and UV fluorescence and absorption spectra of the Tb^{3+} ion in the $LiLuF_4$ single crystal host, as they are excited with laser radiation from the fluorine pulse discharge, molecular laser at 157.6 nm. This pumping arrangement populates the levels of the $4f^7 5d$ electronic configuration from the ground level of the RE trivalent ion, via one photon transition only. The subsequent deexcitation mechanism of the $4f^7 5d$

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